Research Progress 1968

PACIFIC SOUTHWEST Forest and Range Experiment Station

FOREST SERVICE
U.S.DEPARTMENT OF AGRICULTURE
P.O. BOX 245, BERKELEY, CALIFORNIA 94701

A Better Habitat for People

In this world of ours, where growth and technological improvements are rapidly changing our way of living, we are becoming increasingly concerned about the quality of our own environment. There is no doubt that the habitat for people is deteriorating. This is true not only in highly developed areas such as towns and cities, but also in the countryside where the use of resources has altered the natural qualities of the land, and where people themselves by their very numbers, are eroding the land.

In California and Hawaii, we're feeling the pressure a little more than most, as our own swelling population must make room for large numbers of visitors. Here we have an opportunity to begin work on the problem . . . to show through research and good land management how impacts on the land can be reduced.

Of course, we've been doing this in one way or another for years. But increasingly foresters and land planners must think in terms of the total environment . . . of the effect each acre of land and its use has on the rest of the country.

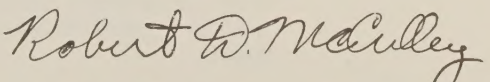
On the one hand, urban influences can damage forests. In the Los Angeles Basin, smog blown up out of the valley into the mountains is killing ponderosa pine trees around scenic Lake Arrowhead. People moving their homes farther out into the steep, brush-covered hillsides create fire control problems worse than any we've ever known in the past, and may reduce watershed values through erosion or pollution. Campgrounds and other recreation areas are hard put to meet the demands.

On the other hand, use of forest lands can create impacts on the urban environment. Poor logging and road building can increase sediment in streams, reduce trout fishing and salmon spawning, and lower the quality of water for agricultural, industrial, and other uses. Indiscriminate use of insecticides can damage the wildlife resource.

The list is long and gives us plenty to work on. In the following pages I think you will find ample evidence that we are working on these problems. Our scientists are exploring ways to create less persistent insecticides, smog resistant trees, more attractive landscapes, better planned development of the countryside, less sediment in streams, better fire protection, and in general improve the productivity of forest lands.

In the future, too, we will become increasingly involved in efforts to bring forestry to the cities. The benefits that wildlands can have on people's physical and mental well-being can be obtained as well, or better, a few miles or a few steps from home.

I expect that forestry research will be increasingly concerned with all the problems involved in creating a better habitat for people. It is certainly one of the most important tasks to which we can turn our thoughts and our labor. We appreciate your interest and support.



Robert D. McCulley, Director

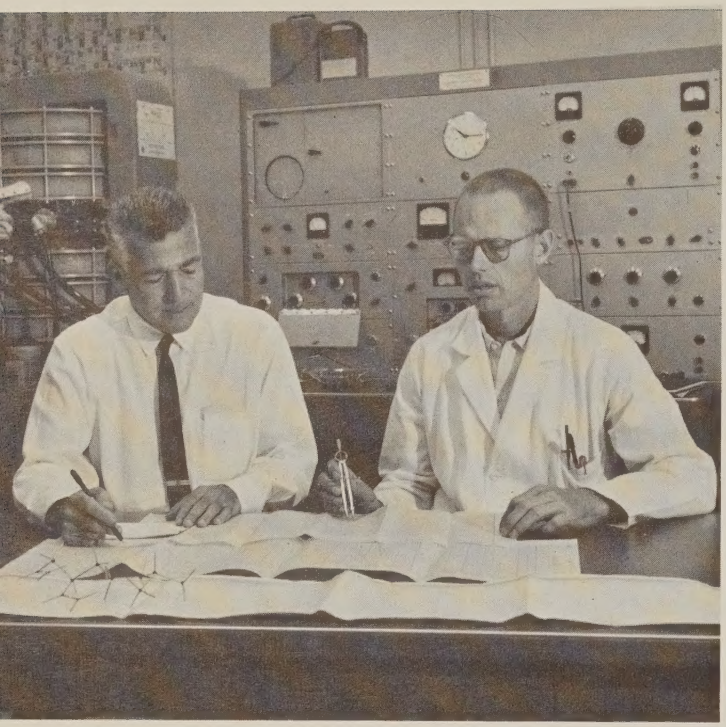


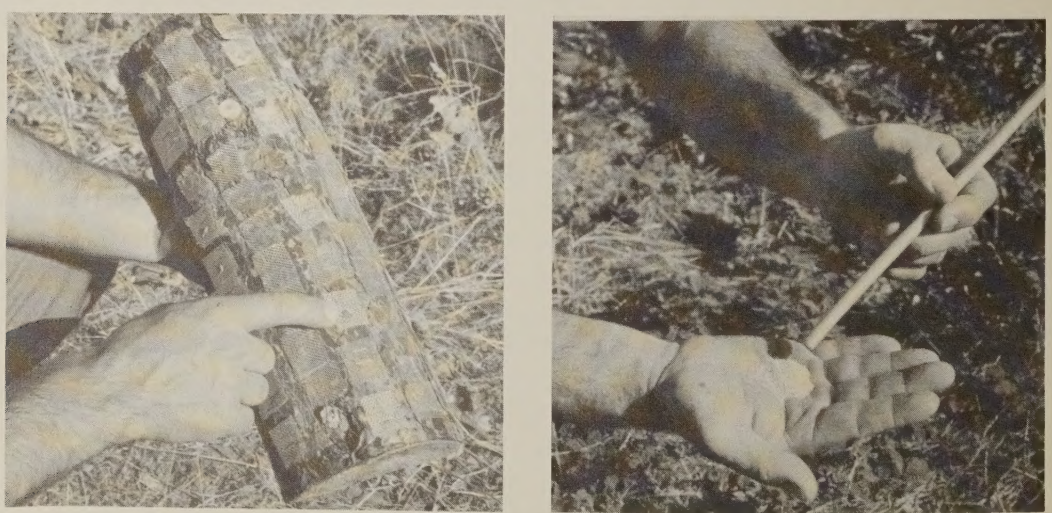
Photo: Stanford Research Institute

Scientists at Stanford Research Institute in Palo Alto use a spectrophotometer (background) to help identify the many components of the bark beetle's sex attractant. So far, they have identified brevicomin and myrcene, but believe more will be found.

SEX ATTRACTANTS FOR

Myrcene Increases Power of Sex Attractant

At least 20 years ago, researchers noticed that the combination of bark beetles and the trees they were attacking brought in other bark beetles by the droves. Now they have reason to believe that this strong attraction is the result of a natural synergism . . . the power of a compound to act more strongly than the sum of its constituents. The compounds involved are brevicomin, a chemical produced by the western pine beetle, and myrcene, a monoterpene found in pine resin. In 1967, scientists identified brevicomin as the principle component of the beetle's sex attractant. It was highly attractive to insects both in laboratory and field tests. This past year, chemists increased its power by adding myrcene, which by itself is not at all attractive. The research, financed by the U.S. Forest Service and conducted by scientists from the Experiment Station, University of California, and Stanford Research Institute, brings still closer the day when sex attractants may be used to control bark beetles, the number one insect problem in North American forests.



Bark beetles attacking a tree or log bolt are still more attractive to other beetles than the synthetic material. In field tests, bolts with attacking beetles (left) are used as a yardstick against which to measure the power of the artificial attractant (right).

BARK BEETLE CONTROL

The attractant is placed in a slim tube which is then raised into a pine tree, until it is about 20 feet off the ground. Then a "sticky trap" is placed around the attractant. As bark beetles fly toward the evaporating attractant, they are caught in sticky wire mesh (insert above). Entomologists count the insects to determine the effectiveness of the compound.

Dwarf Mistletoe Attack Related to Tree Height

A new finding about dwarf mistletoe in red fir stands may ease forester's problems with this disease as management of red fir stands becomes more commonplace in northern California. Forest pathologists have noticed in the past that trees up to about 3 feet in height were not usually infected. This set them to wondering if there was some "magic age" at which trees began to be receptive to the parasite. In a study begun in 1966, they checked both tree age and height as possible factors. With all the data in, it appears that tree height is the most important factor. Both the number of trees infected and the number of infections per tree is directly proportional to height. For example, only seven percent of trees 0–3-feet high were infected. In the 10–12-foot class, however, 79 percent of the trees were infected. The study has important implications for controlling the disease. Pathologists recommend clearcutting in small blocks or strips, selective cutting, and seed tree harvest methods, rather than clearcutting large blocks. Because trees will not generally be infected until they are three feet high—or 10–20 years old—this gives foresters more time to establish regeneration before cutting adjacent stands from which the infection spreads.

New Spray System Effective

A new aerial spray system, developed by the Forest Service Equipment Development Center at Missoula, won the respect of pilots, researchers, and pest control specialists during field tests this past summer. It was designed at the suggestion of the Experiment Station's insecticide evaluation research unit to produce the fine spray drops which previous research has shown are most efficient in applying the insecticide Zectran® to control the spruce budworm. Most spray systems give a full range of drop sizes, but the Missoula-designed system eliminates all drops over 120 microns in size. The insecticide is mixed with the chemical Freon—a common aerosol propellant—as it is put into the aircraft. As the fluid is forced out of the nozzles, the Freon expands rapidly, breaking the insecticide mixture into fine drops.

Fungicides Tested in Tree Nursery

Soil fungicides are being tested at the Placerville Forest Nursery in the hopes of developing treatments which can be used instead of soil fumigants to control the many pathogens which attack young trees. Fumigants are usually applied to the soil in the spring before planting. Unfortunately, fumigation requires a two-week waiting period so the chemical can escape from the soil before planting. If a spring is unusually long and wet, however, there may not be time to fumigate before planting. Fungicides, which require no waiting period, could be used as an alternative treatment in wet years. So far, the mixtures Captan-PCNB, Terrazol-PCNB, Dexon-PCNB, and Dupont 1991 are most promising.

Color Film Detects Smog-Damaged Ponderosa Pine

Remote sensing specialists and forest pathologists have teamed up to work on aerial photo techniques for detecting and evaluating forests damaged by air pollution. Some 56 film-scale combinations were tested in the Angeles and San Bernardino National Forests where ponderosa pine trees are dying from the effects of smog. Anscochrome D/200 film proved best with a special didymium (rare earth) filter to emphasize both the green of healthy trees and the yellow of dying trees. The rather large scale of 1:1,584 was best for evaluating crown color and needle characteristics. A much smaller scale, 1:8,000, with haze cutting filters, was most efficient for initial detection of smog-damaged areas. Our research on the smog-disease problem is sponsored in part by the U.S. Public Health Service, which hopes to develop a system for nationwide detection and evaluation of smog damage in forest and agricultural areas.

Electronic Snoops Detect Bug Trees—Again

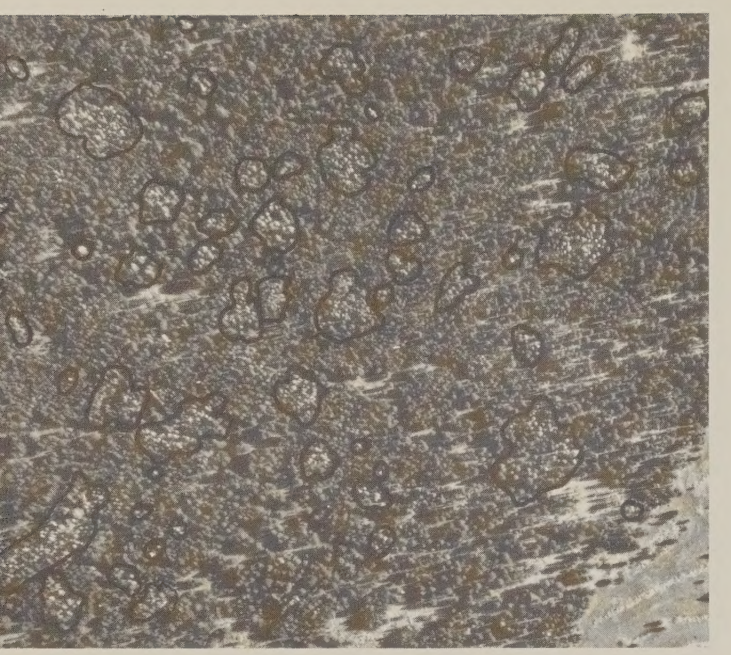
Remote sensing specialists repeated a feat this year which they accomplished first three years ago, but hadn't managed to do since. In the summer of 1965, working in a Michigan State Forest, they were able to detect dying trees from the air before there were any apparent visual symptoms. This was accomplished with an airborne thermal optical-mechanical scanner which measured the temperature differences between healthy and attacked trees. The next two years, the research group changed their airborne gear and moved to the Black Hills of South Dakota. The technique didn't work so well there, and we began to wonder if the first success had been a fluke. This year another switch was made to a more advanced multiple-channel detector system operated by the University of Michigan Infrared and Optical Sensor Laboratory. This airborne electronic snoop may have been more sophisticated, but it meant our scientists had to revise their methods. Recognition of dead and dying trees was accomplished this year by recording information about them in 15 filtered visual and thermal channels. The data was then recombined in a multispectral display which separated dead and dying trees from healthy ones. Now we know it *is* possible to detect

Helicopter carrying heat sensors flies low over test plots to detect trees infected with root rot. In close up at right, Research Forester John Wear demonstrates use of camera and heat sensing equipment. Above, a TV monitor shows forest scene which is also recorded on video tape for later playback. Photos: Ampex Corp.

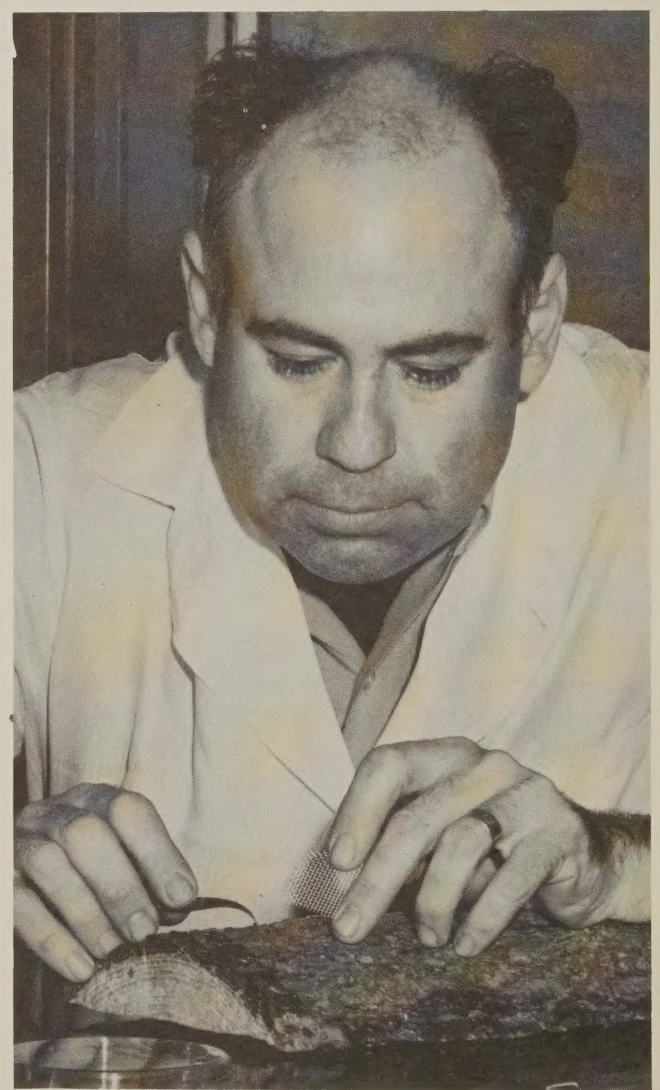
previsual symptoms—or temperature differences—even before a tree begins to change color and look "sick." This success will be a stimulus for increased research in an effort which may someday permit much earlier detection of insect and disease outbreaks.

Aerial Scan System Developed

Remote sensing specialists have found that Douglas-fir trees attacked by *Poria weirii* root rot in the Pacific Northwest also run higher temperatures—at certain times of the day and seasons of the year. But how can these feverish trees be located from the air? One possibility was demonstrated this year. An infrared sensor connected to an instant replay video tape recording system was mounted in a helicopter to "sense" from 150 feet above the tree. When fully developed, the system should be an efficient method of surveying forests quickly for root rot disease. The instant replay enables the observer to review a forest scene he has just passed, much as television gives us instant replay during football games.



Two different views help entomologists determine the number of bark beetles in the woods. Above: aerial photos indicate the number of damaged trees. And X-ray of a section of bark brings bugs "out of hiding" so they can be counted. Both estimates, plus other data, are needed to determine the probable trend of an outbreak. For example, are female insects laying more or fewer eggs? Insects are taken from the bark and reared to maturity in the laboratory to find out.



Cause of Insect Epidemic Determined

Experiment Station entomologists and remote sensing experts have determined the major cause of an outbreak of western pine beetle in ponderosa pine forests of northern California. A high stand density (two to three times normal) allowed the beetles to build up. The epidemic covers some 30,000 acres of National Forest and private land at McCloud Flat on the southeast slope of Mt. Shasta. About one-third of the infested area is overstocked with trees. Plans are underway to thin the stands and improve their vigor.

The study is part of continuing research on the population dynamics of bark beetles . . . what causes outbreaks and why they decline. Since the beetles stay in the bark during most of their life cycle, it has been difficult to even determine the number of insects present at any one time. X-rays provide the answer. Estimates obtained this way, plus estimates of tree mortality from aerial photos, will help entomologists determine whether the outbreak is declining or still on the upswing.

Systemic Insecticide Protects Pine Seeds

Systemic insecticides which are absorbed and translocated by the tree are especially promising for control of cone and seed insects, because these pests live inside the pine cone and are protected from conventional insecticides during most of their life cycles.

One systemic, dimethoate, shows promise of controlling a serious pest, the ponderosa pine seed worm. Trees sprayed with a one percent dimethoate solution lost only 3.3 percent of their seed while 16.6 percent of the seed from unsprayed trees was destroyed. Value of the seed saved was $6–7 per tree. The study was conducted by the California Region of the Forest Service and the Experiment Station in a seed production area on the Plumas National Forest.

Blister Rust Studied in Central Sierra Nevada

Forest pathologists studying white pine blister rust in California believe that newly-discovered infection centers in the central Sierra Nevada pose little threat to California's white pines. Early this year, National Forest crews found six new infection centers on the Mi-Wok District of the Stanislaus Forest, farther south than it had previously been reported. In July, the rust was found on trees even farther south at Mountain Home State Forest. Experiment Station pathologists have studied the Mi-Wok infections to learn where the rust came from and how fast it is spreading. They have found that the infections date from 1944, a year when weather conditions were particularly favorable, and the spores probably came from forests near Mt. Lassen. The new infection centers are restricted to isolated, moist areas, and probably won't spread much, pathologists believe. Control of the disease, however, is recommended wherever it is found.

Grant Received for Automated PI

A continuing grant from the National Aeronautics and Space Administration has made it possible to begin development of automated techniques for scanning and interpreting aerial photographs. The goal is to speed the time-consuming and costly process of extracting data from photographs with conventional methods. So far, two statistical models have been tried to discriminate between forest stands by automatic photo scanning of black and white prints. One model correctly classified 97 out of 100 data cells as to forest type—conifer, open conifer, conifer-hardwood, or hardwood-conifer. When fully developed, this technique will enable rapid and automated separation of much more complex forest types.

Pine seed worms riddle a ponderosa pine cone. Cone and seed insects are especially bothersome in areas where foresters are growing trees especially for their seed. In one recent year, 40–80 percent of the seed crop was destroyed in 9 seed production areas managed by the Forest Service in California.

The effects of herbicides to control brush are strikingly apparent in this northern California brushfield, which was cleared and planted to ponderosa pine in 1962. In sprayed areas (top), five-year-old trees are growing at site potential. Where herbicides were not applied, trees are overtopped by brush. Both photos were taken in 1966.

Brush Control Stimulates Tree Growth

In a northern California brushfield, cleared by bulldozing in 1961 and planted to ponderosa pine in 1962, the effect of herbicides in controlling unwanted brush is now strikingly apparent. Where herbicides were applied, young pine trees are now growing well. But in unsprayed areas, trees have declined in vigor. Many have died from excessive brush competition, and subsequent insect attack. Measurements made in 1968 show that tree height and growth rates are closely related to the degree of brush control which had been achieved by 1966. For example, where brush crown volume was less than 6,000 cubic feet per acre, trees averaged 60–64 inches tall. Where brush volume was greater than 28,000 cubic feet per acre, trees averaged only 28 inches high.

Trees Released by Brush Removal

Brush control may also be desirable to increase the growth of young trees where soils are shallow or rainfall is low. This conclusion comes from a study of one poor-quality site in the Shasta-Trinity National Forest. The site, which supports a scattered stand of pole-sized ponderosa pine and a dense growth of manzanita, was partially cleared of brush in 1962, giving our researchers a chance to study subsequent tree growth. By 1968, the stems of released trees had increased their diameter 178 percent over those of adjacent unreleased trees. Brush removal alone may stimulate basal area growth even more than thinning. Height growth, too, increased markedly during the five years following release, exceeding previous growth by 127 percent.

Landslide Hazards Under Study

Throughout large regions of the western United States, landslides are often the costly consequence of poorly-planned logging and road building. Although damage can be significantly reduced by avoiding disturbance of known slide areas, new methods of analyzing slope stability are necessary to forecast the effects of land use in areas where no slides have occurred. An engineering geologist at the Experiment Station is working on a new method for predicting slope stability which is now being tested in Marin County on the Franciscan formation common to north coastal California. By correlating factors such as slope geometry and rock properties, which are associated with landslides, geologists hope to be able to predict hazard areas for similar rock and terrain types.

Wood Quality Related to Elevation of Seed Source

Specific gravity is one measure of wood quality. Dense, strong wood of high specific gravity is preferred for most uses. From a test begun near Placerville, California, in 1938, forest geneticists have learned that the specific gravity of ponderosa pine is inversely related to the elevation of its seed source. Seed from seven elevational sources was planted at 960, 2,730, and 5,650 feet above sea level. After 29 years, tree height varied considerably by planting site and seed source, but specific gravity was directly proportional to elevation of seed source at all three sites. Low elevation seed produced trees of high specific gravity, and high elevation seed produced trees of low specific gravity. Because tree growth is also an important factor geneticists recommend the following guidelines: to get trees with good volume growth and denser than average wood, seed from 2,000- to 3,000-foot elevation zones should be used regardless of the planting site. To obtain good volume growth of less-dense wood at high elevation sites, use local seed sources.

Snow Damage Heavy in Unthinned Plantation

Foresters should be alert to the possibility of heavy snow damage in young ponderosa pine plantations. One unthinned 17-year-old plantation our researchers studied suffered extensive breakage during the winter of 1967–68. Trees were on a high-quality site at 4,100 feet elevation in the Sierra Nevada. Damage increased with the number of trees per acre. Damaged portions of the plantation had basal areas averaging 193 sq.ft. per acre; while undamaged areas averaged 147 sq.ft. Breakage was most frequent in dominant trees. Broken trees averaged 5 feet taller than their unbroken neighbors.

Snow Gage Gathering Data

Further work on the radioactive profiling snow gage, developed by Station scientists several years ago, has resulted in a gage which can be remotely operated. With it, researchers have learned, contrary to current scientific belief, that heat from the soil has little effect on snow melt in the Sierra Nevada. Snowpacks remain at 32° F. all winter and do not have a strong vertical temperature profile as in the Rocky Mountains. In the Sierra, frequent warm, sunny weather between snow storms melts the snow at the surface during the day. It then freezes at night. The resulting ice layer prevents cold surface air from entering the snowpack.

Water Loss Can Be Predicted

A series of simplified equations have been developed which now make it possible to predict evaporation losses from snow with only the simplest of weather data—temperature, wind movement, and relative humidity. Previously, researchers used theoretical equations which required much more complex data. Now they have taken these theoretical equations—which have been used for many years—and revised them, based on laboratory studies of snow evaporation. Then they went a step farther and developed simplified formulas which are easy to use and still are 80 percent accurate. Knowledge about evaporation losses from snow is essential for operation of water storage reservoirs, and to determine when evaporation suppressants can be used economically to reduce water loss at the snow surface.

Sorting Theory Reduces Costs

At many stages in the processing of raw materials, it is necessary to sort them . . . to determine which will be manufactured into the high-grade finished product, and which will be discarded or sent to a different process. Efficient sorting practices often make the difference between an operation which is profitable and one which is not. Using a pencil slat factory as an example and a source of test data, our researchers have developed a mathematical theory for sorting materials efficiently. A set of computer programs, with linear programing at the core, was written to process data and test decisions. In the pencil slat factory, the result was improved sorting of pencil blocks—at one stage in the production line. The programs were also used to simulate different saw configurations which resulted in a marked reduction in production costs for the factory. The theory is applicable, not only to the sorting of pencil blocks, but to all one-stage sorting problems—whether they are in a cutstock factory, a sawmill, or any other business.

Forest Sampling Improved

A new multi-stage probability sampling design, used last year to estimate timber losses from insect attack, has been extended for use in forest inventories. It will enable the forest manager to use existing resource information in the design of new special-purpose inventories.

A new mathematical theory has also been developed which will help decide how much to spend at each stage of multi-stage probability sampling. The result will be to provide a specified sampling error at least cost.

Aerial photographs in Lassen

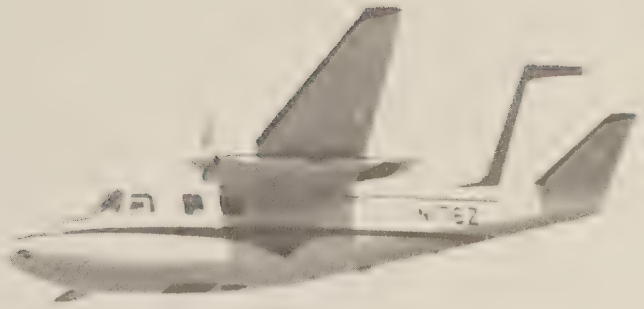
Photo: Pacific Gas and Electric Co.

Stream Habitat Studied

In many streams, trash fish have taken over and the quality of the fishing has deteriorated. One example is Hat Creek in Lassen County where a group of conservation organizations and agencies are attempting to create a quality wild trout fishery along a 4-mile stretch of the stream. Cooperating in the effort are the California Chapter of Trout Unlimited, Pacific Gas and Electric Company, the California Department of Fish and Game, the California Wildlife Conservation Board, and the California Cooperative Fisheries Unit of the U.S. Fish and Wildlife Service at Humboldt State College. At the request of this group, our remote sensing and wildlife habitat specialists are studying large-scale color and color infrared aerial photographs to determine if they can be used to evaluate stream habitat. Replacement of trash fish with trout may trigger an increase in aquatic vegetation—thus it is important to be able to measure aquatic vegetation. At the largest two photo scales (1:600 and 1:1,584) it has been possible to identify nearly all beds of vegetation. Examination of the color infrared film suggests that it may be possible to estimate the condition of the beds. Studies are underway to determine whether it is possible to measure other stream habitat factors—such as stream depth and bottom type—using advanced interpretive techniques.

Fisheries experts sample fish population of Hat Creek (left) before poisoning and restocking with large brown trout. Above left: Experiment Station researchers measure factors such as stream depth, bottom type and aquatic vegetation to provide ground truth as part of aerial photo-interpretation.

taken of Hat Creek County



Remote Sensing researchers fly low over Hat Creek to obtain aerial photographs. Picture below is an example of the kind of detail possible with large-scale imagery (scale 1:1,724). Black and white print is from a 70 mm. color transparency. In color and stereo, the vegetation and stream bottom characteristics are much more apparent, indicating some stream vegetation in this case.

Quail Eat Well After a Burn

California quail seem to get along just fine after controlled burns for range improvement, at least in some habitats. From a study near O'Neals, California, our researchers have found that quail eat about the same foods after a fire as they did before. The study area was annual grass range with brush, pine, and oak. One site was burned; the other unburned. In both areas, quail ate mostly legume seeds; fire apparently did not destroy much seed. Legume seeds made up 66–80 percent of the diet. It is doubtful that any adult birds were killed, and there was little effect on young quail. As soon as the fire was out, the quail moved back into the burned area to feed again.

Youths Learn Computer Skills

A program which began at the Experiment Station to teach disadvantaged youths computer skills has been expanded and is now providing skilled employees for the growing computer industry. It started in September of 1967 when the Berkeley Neighborhood Youth Corps assigned four youths to work at the Experiment Station. Under the direction of interested specialists in the Biometrics Section, the youngsters were soon correlating data, operating keypunch machines, sorters, and reproducers. Eventually, individualized instruction was started for 21 students. Now the program includes classroom instruction by IBM in San Francisco, on-the-job training at offices of local public and nonprofit agencies, and job placement service by the City of Berkeley's NYC, an OEO financed program. Of the first 21 trainees, 10 found jobs in the computer industry, one entered the skill center, two accepted jobs outside the industry, and one dropped out. The other seven worked in computer-oriented industries this past summer and enrolled in college. A second class was started for 26 youths in August.

PPB System Developed

Two research groups at the Experiment Station are working on various aspects of program planning and budgeting. One group, the Management Sciences Staff, has developed the initial model for a Planning-Programing-Budgeting System for the Eldorado National Forest. The system is now being considered for use throughout the California Region of the Forest Service. The Staff used mathematical techniques and a computer to generate a total of 50 alternative budgets. They did not vary much in terms of cost, but differed widely in the combination of outputs—forest goods and services—which would result. The best budget was selected by the Forest Supervisor on the basis of desired outputs for given total costs. The result of PPBS is to permit available dollars to be allocated to the combination of programs which will have the highest potential economic payoff.

RAM in Final Testing Stage

A second research group is concentrating on development of RAM — a Resources Allocation Model — which can be used in preparation of long-range multiple-use plans for wildlands. The testing of RAM on a National Forest Ranger District in California is nearing completion. Electronic computers are used to generate and test several plans for the same area. As a result, land managers can estimate the impact on the land of varying the production of some of the outputs and services. For example, RAM can be used to estimate the effect of increasing recreation use on the production of other resources—water, timber, and grazing. The management plans prepared by RAM are efficient in the sense that they maximize the economic payoff of each plan. RAM will have wide application for all types of forest management since the definition of payoff can be modified to reflect the goals of either public agencies or private firms. Until consistent estimates of the benefits from wildlife and recreation management are obtained, RAM cannot be used to plan these activities. However, the multiple-use management plans prepared so far by RAM do insure the protection of wildlife habitats, and maintain the esthetic qualities of present and future recreation areas.

Computers Can Help Map "Seen Areas"

"Seen areas," or land which can be seen from a road or vantage point, are of special interest to forest land managers. In the past, researchers working on this concept have had to map the areas by hand—while driving or walking along a road or trail. Now they have worked out a computation procedure which can be used to map seen areas by computer, using only elevation data from maps. It is both fast and economical. An extension of this study will also enable forest managers to compute the number of times a given piece of land can be seen from a road, thereby helping in the selection of sites where forest developments would be highly visible.

Forest Landscape Described

A major contribution to forest landscape planning is a newly published report titled, "Forest Landscape Description and Inventories—a basis for land planning and design," *Research Paper PSW-49,* by R. Burton Litton, Jr. Working under a Forest Service grant, the University of California professor of landscape architecture has provided a set of terms and definitions which will allow foresters, engineers, landscape architects, and others to "speak the same language" about the forest landscape. The report also describes how to go about a landscape inventory, and includes an analysis of the scenic qualities along a part of U.S. Highway 50 in the Eldorado National Forest.

Vegetation Improving in Campgrounds

Vegetation in some campgrounds may be improving instead of deteriorating under normal use. Studies at five widely distributed sites in California showed that between 1961 and 1966 there was generally an increase in the number of trees and shrubs. The ground area covered by plant litter, and the amount of vegetation between camp units also increased. Improved conditions may be due to installation of auto barriers, climate changes, or other factors. Continued study of campground ecology will be needed to pin down responsible factors and determine how much people-traffic campgrounds can bear.

Two of the striking photographs in the Litton report illustrate the wide variety of scenery he has classified. Above: Mt. Shasta is described as a "dominant cone form, massive scale." Below: racoon tracks become an "ephemeral landscape, signs."

Value of Forest Products Increases

The value of primary forest products harvested in Hawaii in 1967 was $334,000, a 24 percent increase over 1958, a recent survey indicates. A strong increase in the amount of sawlogs harvested indicates a swing toward the more industrial-oriented uses such as lumber and plywood. Harvest of tree fern was also up, while the volume of fuelwood and posts has declined.

New Tree Species Planted in Hawaii

Seedlings of trees from the South Pacific, Central and South America, and Africa were planted this year at 8 sites in Hawaii. Their performance will be evaluated to determine which are best adapted to the variety of growing conditions in the Islands. In the past four years, 85 species have been planted in 15 locations in a research effort seeking better trees for timber, and for improvement of recreation, esthetics, wildlife habitat, and watershed values in Hawaii forests.

Durability of Wood Tested in Hawaii

The year-round warm, humid climate of Hawaii is delightful for humans, but also for wood destroying fungi and insects. Studies of the natural durability of several woods used in Hawaii are beginning to show conclusive results. In-the-ground and above-ground, redwood is much more resistant to decay and termites than any other wood tested. Saligna eucalyptus and robusta eucalyptus rank next best, ahead of Douglas-fir, Philippine mahogany, and blackbutt eucalyptus. All are proving more durable than western redcedar, which is usually considered equal to redwood. Tropical ash is the least durable of the woods tested, and has proved considerably less durable than koa and white oak, which in turn are worse than Australian toon, ohia-lehua, silk-oak, and meranti.

Soil Productivity Studied in Hawaii

The wide variety of soils in Hawaii differ greatly in their ability to grow timber. Also, there are wide differences in growth of different tree species on a given site. Yet efficient forest management requires predicting timber yields. To develop an index of soil productivity for several timber species, soils are being examined and classified in plots in over 650 planted stands in Hawaii. In addition, permanent growth plots have been established in 25 stands. These will be remeasured periodically. The U.S. Soil Conservation Service and the University of Hawaii are cooperating in the soil productivity studies with the Station's Institute of Pacific Islands Forestry.

FAMULUS Saves Scientists' Time

Most researchers try to maintain personal files on information cogent to their work. Computers can relieve the scientist of much of the drudgery of maintaining and updating his files. A system designed for this purpose is FAMULUS, a family of computer programs which can edit, index, revise, and search these personal documentation systems. The concept was first presented in 1966 by the Station's librarian at the American Water Resources Conference in Chicago. Development of the system was sponsored in 1967 by the Washington Office of the Forest Service, and this past year FAMULUS products were used by the Washington Office Division of Information and Education, and by three Experiment Stations: the Pacific Southwest Station at Berkeley, the Pacific Northwest Station at Portland, and the Rocky Mountain Station at Fort Collins. The programs are now working on a CDC 6400 computer. An IBM 360 version is expected to be ready for use in 1969.

Soil-Vegetation Survey Maps 200,000 Acres

About 200,000 acres were mapped this year by the California State Cooperative Soil-Vegetation Survey, bringing to 10,763,000 acres the total land mapped in California since 1947. Portions of Butte, Calaveras, Plumas, Tuolumne, and Tulare Counties were done this year, including Mountain Home State Forest and Calaveras Big Trees State Park. In their wide rangings throughout the State, the survey crews picked up many interesting bits of information which can be helpful in land management. For example, crews have found water repellent soils under fir forests and brushlands, particularly on the Lytton soil series above 5,000 feet.

Land Use Affects Soil Characteristics

Although considerable research has been done on Hawaii's soils, information is lacking regarding the moisture regime of soils when subjected to different land uses. Research on the Island of Oahu indicates that changing the land use may drastically alter the hydrologic characteristics of the soil. Infiltration rates under forest cover were more than 5 inches per hour. But rates for the same soil series under sugar cane and pineapple were less than 1/10-inch per hour. The same soils under a forest cover have larger surface soil aggregates than those under cultivation and are therefore less erodible. The finding has implications for land management in Hawaii sufficient to warrant further study.

Wetting Agent Gets Major Test

For the past five years, watershed scientists in southern California have been studying wetting agents as a method of reducing erosion and runoff from burned watersheds. This year they began the first large-scale test on a 274-acre watershed near Glendora which burned in July. Pure wetting agent was applied by helicopter at a rate of 6.67 gallons per acre, at a cost of $24 per acre. The treatment is being tested as a way of counteracting a water repellent soil condition often associated with burned watersheds. In prior tests on small plots, wetting agents have reduced runoff an average of 40 percent, and erosion by 35 percent. Cooperators include the Angeles National Forest and the Los Angeles County's Flood Control District and Fire Department.

In continued research on the problem of water repellent soils, the same research group has been the first to measure soil temperatures during a wildfire. Highest surface temperature recorded was 1,380° F., about as expected. One inch below the surface, a high of 320° F. was recorded. But four inches down, only slight temperature rises were noted.

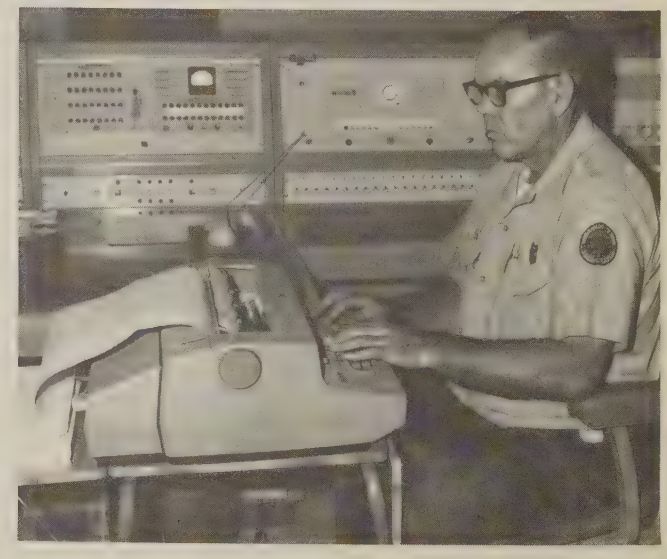
Photo: Glendora Press

Los Angeles County Fire Department helicopter ferries experimental equipment to a burned site near Glendora in southern California. After equipment was set up, wetting agent was applied (below). Scientists will measure runoff and erosion in the study area throughout the winter.

Fire Dispatching by Computer

Fire dispatchers for the California Division of Forestry in San Bernardino got their first experience in 1968 with a computer dispatch system developed by fire scientists at Riverside. This system is the first of its kind in the world and consists of a typewriter-like terminal in the dispatcher's office connected by telephone line to a computer 70 miles away in Los Angeles. The dispatch system covers the State-protected area of the San Bernardino Mountains and surrounding forest area. Thousands of bits of information about the area's roads, travel times, and available firefighting forces are stored in the computer. During the course of a fire, the dispatcher maintains a continuous dialogue with the computer . . . using it to keep track of men and equipment, and decide what firefighting forces to dispatch. Though the system proved highly useful, researchers plan improvements which will make it faster, cheaper, and more foolproof.

```
 LOAD(GO,GO)
\XEQ GO
DO YOU HAVE A FIRE ??
\YES
WHERE IS THE FIRE
NHOME
\52
ENTER 0 TO SUPPRESS ROUTES ELSE ENTER 1
ENTER NO OF RESPONSES YOU WANT FROM TO
NCOLST
\1,1,3
690109     1153
RESPONSE NO. 1. IS FROM NODE 9.  ETA IS 5.  MIN.
TRAVEL IS FROM NODE 9.  TO NODE 52.

EQUIPMENT AT THIS STATION IS:
          580    CDF FTH 500 GAL

          584   CDF FTH 500 GAL

690109     1153
RESPONSE NO. 2. IS FROM NODE 3.  ETA IS 12.  MIN.
TRAVEL IS FROM NODE 3.  TO NODE 50.
               NODE 50.  TO NODE 51.
               NODE 51.  TO NODE 52.

EQUIPMENT AT THIS STATION IS:
          562   CDF FTH-4 500 GAL

          567   CDF FTH-6 1000 GAL

          589   CDF FTH 500 GAL

          101   CDO FTH 500 GAL

690109     1155
RESPONSE NO. 3. IS FROM NODE 8.  ETA IS 17.  MIN.
TRAVEL IS FROM NODE 8.  TO NODE 31.
               NODE 31.  TO NODE 34.
               NODE 34.  TO NODE 36.
               NODE 36.  TO NODE 9.
               NODE 9.  TO NODE 52.

EQUIPMENT AT THIS STATION IS:
          570   CDF FTH 500 GAL

ENTER CHANGE
ID
\580,52
ID
\562,52
```



Above: U.S. Forest Service and California Division of Forestry personnel confer on the computer dispatch system tested by CDF at their San Bernardino headquarters this past summer. Right: dispatcher uses a typewriter-like terminal which enables him to talk to the computer by direct telephone line. Above right, typical dialogue between dispatcher and computer.

Crushing Slash Reduces Fire Hazard

A small tractor with a compactor-cutter-crusher unit can be used to reduce fire hazard after precommercial thinning in ponderosa pine. In tests on the Deschutes National Forest in Oregon, the hazard was reduced in both green and 1-year-old slash. Standing trees were not damaged and the appearance of the areas was improved. Fine fuels were broken up and partially mulched into the soil. Slash was left close to the ground where it will stay wetter and decay faster. This method of treating slash is suggested where some fire hazard can be tolerated, and for large areas where slash is now being left on the ground without treatment. Cost was $15 to $25 per acre, considerably less than chipping, burying, or piling and burning.

Fire Violations Reduced by Public Contact

Two years ago, the California Division of Forestry began a study in cooperation with the Experiment Station to learn how to get rural landowners to comply—willingly—with new fire laws. The first year, new fire hazard inspection procedures were initiated in the Butte County study area. Letters were sent to property owners informing them of the new requirements, and follow-up personal contacts were made. The procedures were repeated in 1967 to determine if there would be a carryover effect from the previous year's effort. A reduction from 63 percent of properties in violation in 1966 to 49 percent in 1967 shows a substantial decrease. In many cases, however, personal contact was still necessary to secure conformance. Violation of the law which requires owners to clear debris from around buildings was the most frequent infraction—accounting for 90 percent of the violations.

Rodents Prefer Certain Saltbushes

There is no such thing as a fireproof plant, but fire scientists at Riverside are studying slow-burning ones—principally saltbushes—hoping eventually to substitute them for more flammable plants on fuelbreaks in southern California. One of the problems of introducing new plants on these areas is damage by animals. Which plants will small rodents prefer, and which will they leave? A recent study showed that fourwing and allscale saltbushes (*Atriplex canescens* and *A. polycarpa*) were damaged less by rodents than six other species. Generally, plants from nearby sources were clipped less than those from distant locations.

All Landowners Potential "Problem Burners"

Landowners who burn debris and allow their fires to escape cause about 18 percent of all forest fires in Oregon, especially in the western part of the State. Yet many people burn debris quite safely. What makes the difference? The Oregon Fire Action Council cooperated with the Experiment Station this past year to find out. Our researchers expected that "problem burners" would differ significantly from those who burned debris safely. But under the conditions of this test, no significant difference was found. The conclusion is that all property owners in a hazardous fire area should be considered potential problem burners. Fire prevention efforts must therefore be designed to reach each person. Finding significant differences between the groups would have simplified the fire prevention effort.

Attitudes Toward Vandalism Studied

A study of people's attitudes toward vandalism and carelessness with fire in forests has been made in Utah County, Utah, in cooperation with Brigham Young University. Participants were asked to answer questions such as how they felt about behavior such as flipping a burning cigarette on the ground. Answers were tabulated and compared with the people's backgrounds. Results indicated that those with the most responsible attitudes tend to be older, urban dwelling, experienced with fire, authority tolerant, and generally aware of forest fire danger. Those with the least responsibility were just about the opposite. The study will help in planning fire prevention programs to reach the right audience.

Canyon Winds Studied by Streamline Analysis

Fire meteorologists studying canyon winds under light Santa Ana conditions have found that surface winds are closely related to both the horizontal and vertical winds above the surface. Their study was made in San Antonio Canyon in the San Gabriel Mountains of southern California. By streamline analysis, which gives a vertical cross section of wind patterns, they have shown how rapid wind shifts occur, especially near the convergence of the downslope and lee-trough winds and upslope winds. The data and analyses should help fire managers predict fire behavior more accurately and also give the fire-weather forecaster a better grasp of the reasons for the complexities of surface winds.

Weather radar has proved to be a useful tool for researchers studying experimental fires.

Weather Radar Tracks Air Currents at Test Fire

A pulse-doppler weather radar measured air currents of a 30-acre experimental fire in the Nevada desert in June. Updrafts were measured at about 60–100 miles per hour—about as expected, but downdrafts were stronger than anticipated (40 miles per hour) and came in from relatively high elevations. The experiment, conducted in cooperation with research meteorologists from the ESSA Wave Propagation Laboratory in Boulder, Colorado, has helped establish the continuity of air currents around large fires, and shown that radar can be used to observe and study experimental as well as wildfires.

Experimental Classes Aimed at Youth

In a study conducted for the Experiment Station by Chico State College, experimental classes in conservation and forest fire prevention rated better than conventional courses in the public elementary schools of Butte County, California. Materials were prepared in a semi-programed format for the lower grades, kindergarten through third. Test scores of children in the experimental classes were significantly higher, particularly at the kindergarten and first grade level. The possibility of converting the new courses to educational television, where they could reach a wide audience, is being considered.

CURRENT INVESTIGATIONS AND SCIENTISTS IN CHARGE

Donald W. Lynch, *Assistant Director*

Evaluation of Chemical Insecticides:
Arthur D. Moore (Berkeley)
- Chemistry and toxicology of insecticides
- Biological activity of chemicals
- Movement and metabolism of chemicals in forest plants
- Insect biochemistry
- Spray physics and formulation
- Ecological aspects of chemical control
- Spraying procedures and equipment

Genetics of Western Conifers:
Stanley L. Krugman (Berkeley)
- Natural variation within species
- Inheritance of characters within species, including host-resistance
- Techniques for tree breeders
- Hybridization between species
- Forest botany
- Physiology of cone and seed production
- Inheritance of wood quality

Biology and Control of Forest Tree Diseases:
Robert V. Bega (Berkeley)
- Diseases of seeds and seedlings
- Root disease in natural and planted forests
- Dwarf mistletoe, particularly of true firs
- Effects of air pollution on western conifers
- Hazardous trees on recreation sites

Silviculture of the Redwood Type: *Kenneth N. Boe (Arcata)*
- Intensive silviculture of young-growth redwood
- Regeneration of redwood following harvest

Silviculture of Sierra Nevada Conifer Types:
Douglass F. Roy (Redding)
- Levels of growing stock for ponderosa pine
- Regeneration and cutting methods in true fir forests
- Logging costs in young-growth pine
- Field testing hybrid trees
- Regeneration of west-side ponderosa pine

Measurement and Analysis Techniques for Management Planning: *Philip G. Langley (Berkeley)*
- Automated photointerpretation for forest inventory and management information
- Wildland Resource Information System (WRIS)
- Inventory using multi-stage probability sampling design

Biology, Ecology, and Control of Forest Insects:
Richard H. Smith (Berkeley)
- Bark beetles: population sampling, control by sex attractant, resistance of pine to bark beetles, and variation in ability of insect populations to damage trees
- Biology, ecology, and control of lodgepole needle miner, cone and seed insects, and fir needle miner
- Impact of Douglas-fir tussock moth on white fir
- Tree resistance to insect attacks

Edward M. Gaines, *Assistant Director*

Management of Annual-Plant and Related Ranges:
Raymond D. Ratliff (Fresno), Acting
- Comparison of seasonal and year-long livestock grazing systems
- Grazing management of fertilized ranges

Flood and Sediment Reduction in Conifer Forest Zone:
J. S. Krammes (Berkeley)
- Effects of timber cutting on soil moisture regime
- Streamflow and sediment production in redwood forests
- Rates and mechanisms of mass soil erosion

Management of Perennial Grass Ranges:
Raymond D. Ratliff (Fresno)
- Rest-rotation grazing management on livestock summer range
- Mathematical simulation of California chaparral ecosystems
- Effect of logging on grazing capacity in the pine type
- Growth, reproduction, and management of bitterbrush in northeastern California

Improvement and Management of Wildlife Habitat:
Richard L. Hubbard (Berkeley)
- Improvement of deer habitat on Great Basin ranges
- Influence of logging and road building on stream ecology and fish habitat
- High Sierra wildlife habitat ecology
- Evaluation of stream habitat by aerial photography

Hydrologic Analysis Methods:
Henry W. Anderson (Berkeley)
- Regional sediment sources and causes
- Multivariate approaches to analysis of watershed runoff and sedimentation
- Hydrologic characteristics of mountain soils
- Major flood effects on watershed hydrology

Brushland Flood and Sediment Reduction:
Raymond M. Rice (Glendora)
- Use of wetting agents for erosion control after fire
- Emergency "first-aid" for burned watersheds
- Storm runoff and erosion from chaparral watersheds

Water Yield Improvement in Conifer Forest Zone:
James L. Smith (Berkeley)
- Relation of snow metamorphosis to incoming heat variables
- Snow hydrology as affected by rain falling on snow packs
- Snow accumulation and melt in forests and open areas
- Effect of soil hydrologic properties upon water flow and plant water use
- Water use by individual trees and environmental effects on timing of use

Soil-Vegetation Survey: *Wilmer L. Colwell (Berkeley)*
- Investigations of the distribution, productivity, and relationships of soils and vegetation in the wildland areas of Butte, Calaveras, Plumas, and Tuolumne Counties

Carl C. Wilson, *Assistant Director*

Fire Meteorology: *Morris H. McCutchan (Riverside), Acting*
- Structure and energy budget of the Pacific Coast monsoon
- Numerical analysis of winds over mountainous terrain in the Pacific Northwest
- Summertime marine air invasion of western Washington
- Influence of atmospheric instability on fire spread
- Summer mesotype weather in the Pacific Northwest
- Three-dimensional structure of the Santa Ana winds
- Investigation of the marine-continental interaction zone of the Pacific Coast

Fire Management Systems: *James B. Davis (Riverside)*
- Classification system for resource values
- Simulation approaches to fire control planning
- Development of INFORMAP system
- Automated system for initial attack dispatch
- Information system for large fire command and control
- Effectiveness of existing fire suppression forces
- Techniques for fighting potential fire disasters

Fuel-Break: *Lisle R. Green (Riverside)*
- Chemical control of brush and herbaceous vegetation
- Fuel reduction through plant growth inhibitors
- Revegetation with plants of low fuel volume
- Prescribed light burning to create and maintain fuel-breaks
- Hazard reduction techniques

Forest Fire Behavior: *Clive M. Countryman (Riverside)*
- Behavior of wildfires and prescribed burns
- Fire behavior case studies
- Studies to provide provisional forest fire behavior data
- Guidelines and training materials for identifying and describing dangerous fire behavior

Fire Chemistry: *A. Broido (Berkeley)*
- Pyrolysis of cellulose and simple saccharides
- Influence of ash constituents on pyrolysis and combustion
- Influence of fire-retardant chemicals on pyrolysis and combustion of cellulosic fuels
- Characterization of smoke from cellulosic fuels

Fire Prevention: *William S. Folkman (Berkeley)*
- Fire prevention knowledge and attitudes
- Effectiveness of fire prevention education
- Relationship of characteristics of conservation agencies to fire prevention programs
- Relationship of personal and social environment factors to fire occurrence

Mass Fire Systems: *Thomas Y. Palmer (Riverside)*
- Theoretical mass-fire models
- Spectral analysis of temperature and air flow in and near mass fires
- Instrumentation systems, including use of radar, microwave, and infrared techniques
- Prototype liquid hydrocarbon mass fire system

Harry W. Camp, *Assistant Director*

Timber Conversion Systems: *H. D. Claxton (Berkeley)*
- Decision procedures for selecting optimum mix of research projects
- Decision rules for determining target sawing sizes
- Decision model for optimum kiln drying schedules
- Optimum inventory levels
- Effects of sorting, sampling, and scheduling procedures on production

Forest Products Marketing: *Harry W. Camp (Berkeley), Acting*
- Marketing of western hardwood and softwood timber products
- Implications of expanding use of wood pallets
- California market for wood highway guardrail posts
- Marketing opportunities for Hawaii's hardwoods

Forest Economics and Multiple-Use: *Daniel I. Navon (Berkeley)*
- Techniques for evaluating multiple-use management alternatives
- Computer-oriented systems for assembling and displaying land management information

Watershed Systems Development: *Clyde A. Shumway (Berkeley)*
- Watershed simulation techniques
- Operations research techniques for watershed program planning
- Computer-oriented systems for data reduction, storage, and retrieval

Remote Sensing of the Forest Environment: *Robert Heller (Berkeley)*
- Remote sensing techniques from earth-orbital vehicles
- Aerial detection and evaluation of forest pests
- Photointerpretation applications in forest resource inventories
- Detecting and evaluating air pollution damage to forests

Forest Recreation: *Robert H. Twiss (Berkeley)*
- Recreation trends and forecasts
- Ecological trends in recreation areas
- Value of recreation expenditures to forest communities
- Plant culture for recreation areas
- Visual aspects of resource management

Timber and Watershed Resource Development in Hawaii: *Robert E. Nelson (Honolulu)*
- Watershed management: evapotranspiration; land use effects on soil hydrology; rain interception and fog drip
- Timber management: silviculture of native and introduced trees; adaptability of introduced species; timber growth
- Forest products: properties and uses of wood of native and introduced trees; wood quality, durability, behavior, and seasoning; manufacturing problems

Management Sciences Staff: *Ernst S. Valfer (Berkeley)*
- Forest Service programs of:
  - Planning-Programing-Budgeting Systems (PPBS)
  - Communication systems
  - National Forest administrative organization
  - Utilization of professional and technical skills

GPO 976-891

The Forest Service of the U.S. Department of Agriculture

. . . Conducts forest and range research at more than 75 locations from Puerto Rico to Alaska and Hawaii.

. . . Participates with all State forestry agencies in cooperative programs to protect and improve the Nation's 395 million acres of State, local, and private forest lands.

. . . Manages and protects the 187-million-acre National Forest System for sustained yield of its many products and services.

The Pacific Southwest Forest and Range Experiment Station

represents the research branch of the Forest Service in California and Hawaii.